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RoboCupRescue - Robot League Team Alcor-Dia, Italy

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Abstract. We present a stable and autonomous system based on a strong interaction between visual cognitive inference and actions executed. Mapping, Vision and Navigation are all collaborative agents that work together sharing data to accomplish to complex identification and mapping tasks. The visual process reacts to interesting features in the arena trying to approach the focused area in order to achieve more successful observations from the environment. This activity is performed coordinating the states that model the robot actions in the arena. A Reactive Planner subsystem includes all the functionalities which are needed for accomplishing the role of harmoniously coordinating and controlling the tasks mentioned above. The hardware architecture is constructed over a ActivMedia Pioneer3Dx, called in the following DORO, endowed of rich sensor's system.

Introduction

We present in this competition an approach to cognitive robotics architecture to detect and identify safety issues in indoor environment. Our approach is based on a good and stable mapping and navigation system, built upon a probabilistic model of sensors data fusion, and a fuzzy controller suitably mixing several behaviors adapting to the situation. The interpretation of sensor's feedbacks by the Reactive Planner process could ensure good plans choices, in order to execute all the rescue activities. Given this basic structure we are experimenting with a complex visual cognitive system able to elaborate over some specific models of texture processing (e.g. wavelet transforms), primitive shape components, and localization of both particular moving features, and unusual people pose and gestures. This kind of visual inference concerns e.g. someone lying on the ground, or targeted gestures for signaling request for help. In the rescue arena scenario this approach leads the robot to behave like a remote and autonomous rescue operator. The main tasks that Doro follows are: exploration of the arena and victim localization. As there is no a-priori initial knowledge about the arena map, the first task is accomplished by giving Doro a 'greedy' behavior versus unexplored regions in the map. This means that Doro is continuously attracted towards zones which have not been visited yet. This task involves activities such: wall-following, door crossing, obstacle avoidance and target approaching. The second task is carried out thanks to Doro's main sensory device: the camera. While moving, Doro registers every significant pattern or texture that may lead to a victim's identification. When a feature, or set of features, identifying a victim, are detected, the main inference system suggest to the navigation module a direction to follow in order to verify if such hypothesis leads to a clear victim's identification.

In short: the robot can be seen as a smart agent driving the attention to promising location in which to discover a victim. When such signs are not perceived, Doro continues his exploration inside the arena building the metric and topological map. All layers involved in this process (mapping, visual perception, navigation, reactive planner) are seen as collaborative agents more than a strict Master/Slave relationship. The visual cognitive system affects motion, the navigation system has access to the map to decide feasible path to target location, the mapping module enrich the topological map with landmarks based on visual perception, and the reactive planner schedules all these activities. All layers involved in this process (mapping, visual perception, navigation) are seen as collaborative agents more than a strict Master/Slave relationship. The visual cognitive system affects motion, the navigation system has access to the map to decide feasible path to target location, and the mapping module enrich the topological map with landmarks based on visual perception. Every participant agent shares a common area in which various tasks and goals are performed and information exchanged, in order to let the information flow run through all layers in a transparent fashion.

Figure 1 - The Rescue Robot that we named DORO.

1. Team Members and Their Contributions

- Prof. Fiora Pirri Visual Cognitive System.
- Andrea Carbone Operator – Navigation, Software Design.
- Giorgio Ugazio Mapping and Localization.
- Marco Iarusso Visual Cognitive System.
- Alberto Finzi Reactive Planner.
- Andrea Orlandini Reactive Planner.
- Prof. Marta Cialdea Reactive Planner.

2. Operator Station Set-up and Break-Down (10 minutes)

Doro set-up requires few steps to be performed. They consist on: turning on of both the operator and remote laptops followed by the connection with the onboard client user interface. These steps allow the operator to gain control over the Robot and to start the exploration of the targeted arena. On top of the robotic platform we placed various devices (cameras, pan-tilt and telemeter). They are all connected to the on-board laptop. All is kept together by a plastic support which contains the laptop and all requested cables and power supply adapters. ActivMedia Pioneer robot is provided with an external handle on the rear in order to let the operator to bring it up and transport like a bag.

3. Communications

The laptop mounted on the top deck of Doro is equipped with an **802.11A** wireless PCMCIA device. This provides access to all the on-board activities via a remote monitoring using an operator laptop which is connected in a peer-to-peer fashion with the Doro laptop. We plan to call this dedicated network: "**DORONET**". We are going to use standard C class 192.168.10.x addresses.

4. Control Method and Human-Robot Interface

In our experiment the operator is directly connected to the on-board laptop. All operations run on the remote laptop. The operator has full access to the remote desktop, in this way the operator sees everything DORO sees. Or, better, sees all what the remote application is programmed to show.
Our goal is to build a completely autonomous system, able to perform all tasks required in a Robocop rescue competition. Alternative operational modes are allowed. These are: *semi-teleop* and *teleop*. In *semi-teleop* mode only main directives are transmitted from the operator to the robot control. Their final execution is left to the navigation routines (avoidance, active vision, features identification etc.). In teleop mode, Doro can be directly guided via a joystick interface to specific locations, using the on-board camera as eyes for the operator.

5. Map generation/printing

The metric map is created during the navigation and is enhanced with additional information regarding victim's position and (when available) the state (awareness, consciousness etc.). The final map can be saved and stored as a common digital image file (JPEG, PNG, and BMP) reporting all the useful information gathered during the session. Most of the data contained in the final map will be automatically generated by the robot itself. Additional informations will be added if considered useful by the operator directly using the client interface.

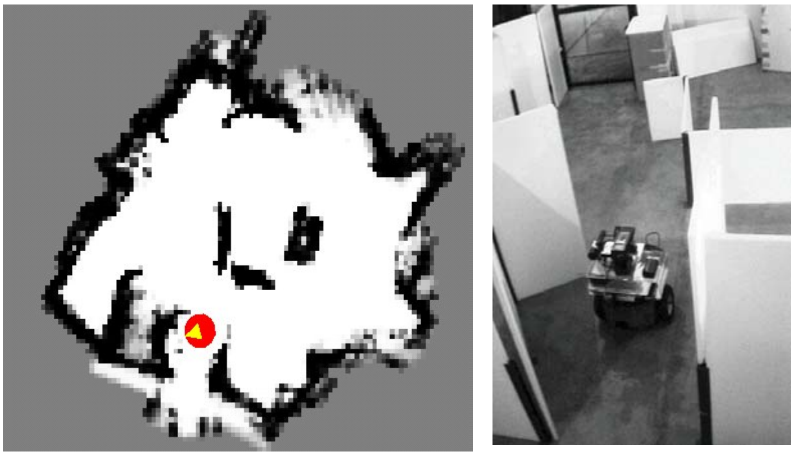

Figure 2 - An early example of a global metric map generated from sonars.

6. Sensors for Navigation and Localization

The pioneer is equipped with 8 Sonar ranging 180° in forward direction. A telemeter is mounted on the same pan-tilt unit that hosts the camera. Sensor data are fused and mapped into local occupancy value. Local occupancy value must be integrated in time to build a single, global, Metric Map using a Bayesian Filter. A Bayesian Filter is a recursive estimator we use to calculate sequences of posterior probability distribution over a quantity that cannot be observed directly: the Map. The final result is a set (a matrix) of cells each representing the probability of being occupied. The sonars produce distances with a short period, so they provide a continuous flow of information to the mapping routines. The telemeter, being joined to the same pan-tilt unit that supports the camera, requires a custom task that provides high-confidence distances when the robot enters a new region. In this domain with high-confidence measure we mean a sensor data that strongly raise the occupancy value of the spatial cell it represents. The localization issues are solved with a fast integration routine of the Inertial Platform data fused with odometric data coming from the wheels.

Figure 3 - These two shots shows an istantaneous Local map and the relative Global map.

7. Sensors for Victim Identification

The man sensor devoted to victim identification is the camera. The visual inference stages is composed by different perceptual stages which goes from an Attention phase in which an interesting ‘feature’ in the environment catches the attention of the agent, to a Cognitive inference based on further (and appropriate) observations are taken into account to guess if all perceptual data collected can lead to a success in the identification of a specified target. The visual process is carried by mean of dedicated image analysis routines that can be grouped in more stages like: segmentation/clustering, edge finding, features extraction (wavelets) and others.

8. Robot Locomotion

Doro is a two-wheeled differential drive robot with a caster on the rear. No particular modifications have been done to the original ActivMedia design for what concerns the locomotion.

9. Team Training for Operation (Human Factors)

The user interface gives the operator a complete control over the robot. So just a basic training in an artificial arena will be useful to take confidence with the controls. Our aim is to build an autonomous system, so the only effort requested to an operator is to familiarize with all the signals and controls provided by the user interface.

10. Possibility for Practical Application to Real Disaster Site

Being based mostly on vision, this system can be highly useful to bring the attention of a remote operator toward specified location of an area that the visual inference system evaluates as a candidate for a rescue action. Basing on the same process the developed visual inference can be applied to a wide range of task that can help a rescue operator to gain informations about the operative condition in a disaster area.

11. System Cost

The economic effort requested by the devices ranges from 8000€ to 10000€. The main cost can be accounted for the mobile robot (half of the overall cost). The entire set is composed by:

- ActivMedia PioneerDX
- Laptop Asus centrino (1.6)
- ImageInAction framegrabber (connects to 1394 firewire)
- Direct Perception PTU
- Xsens MT9 Inertial Platform
- Sony XC99 CCD camera